LA-UR-21-26974
Approved for public release; distribution is unlimited.

Title:	2021 Hagan Container Surveillance Plan
Author(s):	Kelly, Elizabeth J.; Karns, Tristan; Narlesky, Joshua Edward; Davis, John Taylor; Stone, Timothy Amos; Vaidya, Rajendra U.; Kaufeld, Kimberly Ann; Prochnow, David Adrian; Grow, David Isaac; Oka, Jude M.; Smith, Paul Herrick
Intended for:	Report
Issued:	2021-07-20

2021 Hagan Container Surveillance Plan

Table of Contents

1.0 Introduction

Prior to 2021, Hagan containers were examined on an ad hoc basis as part of the SAVY-4000 surveillance plan. Given the size, aging horizon, and unique potential failure mechanisms of the Hagan population, the authors identified the need for Hagan-specific surveillance (Kelly, et al., 2020) and have developed this surveillance plan to meet that need. The goal of this Hagan-focused plan is to provide information to answer the following questions:

1. How should the potential failure modes be addressed to mitigate potential problems? The potential failure modes under normal operating conditions of storage include the following:
    a. Leakage/loss of containment due to closure errors: such as crimping the O-ring while tightening, missing O-ring when closing and under tightening of the lid.
    b. Leakage/loss of containment due to container design issues: non-standard groove size, insufficient O-ring compression, degradation of filter sealant.
    c. Leakage/loss of containment due to corrosion: general corrosion, pitting, and/or stress corrosion cracking (SCC).
2. What are the key material properties that affect the potential failure modes (e.g., age, wattage, radiation fields, storage conditions including relative humidity (RH), temperature, packaging material incompatibility resulting in corrosion and residue deposits, incorrect packaging configurations)?
3. What is the extent and impact of incompatible packing materials and storage outside of bounding conditions of use?
4. Based on surveillance and other studies, what can be inferred about the Hagan container design-life, anticipating continued usage extending out approximately 20 years?

2.0 Background

Hagan threaded closure containers have been in use at Los Alamos National Laboratory since the late 1990s. At the time of implementation they were viewed as the preferred choice for nuclear material storage, but over the decades it has become clear that the Hagan containers have vulnerabilities. The Hagan container has never been the direct cause for an uptake of radioactive material, but there is a history of the Hagan container failing some of the surveillance activities that have been performed on them in the past.[1] The failures include the following:

- Helium leak testing

[1] Karns, Tristan et al., "Surveillance Report on SAVY 4000 and Hagan Nuclear Material Storage Containers Update for Fiscal Year 2019", Los Alamos National Laboratory report LA-UR-19-32444, December 2019.

- Visual inspections identifying corrosion in the threads indicating loss of seal
- O-ring hardness

2.1 The Hagan Population at the Beginning of 2020

Table 1 shows the Hagan population at the begining of 2020 by first use year and container size. There are a total of 2947 Hagan containers and 2551 of these are 10 years of age or older.

Table 1. Hagan containers by first use year and container size

Container First Use Year	**1Q**	**3Q**	**5Q**	**8Q**	**12Q**	**Grand Total**
1999	7	25	23	14	4	73
2000	15	47	18	18	2	100
2001	31	135	71	86	26	349
2002	18	98	50	14	8	188
2003	5	72	40	11	4	132
2004	5	34	50	22	6	117
2005	24	114	240	87	16	481
2006	65	112	113	17	3	310
2007	26	163	62	9	5	265
2008	23	84	47	10	1	165
2009	23	59	57	4	1	144
2010	29	96	89	13		227
2011	25	33	66	24	6	154
2012	4	23	11	31	2	71
2013		12	3	7		22
2014	1		2			3
2015	1	1	1		1	4
2016	21	16	7	6	7	57
2017	4	5	1	3		13
2018	18	11	13	5	2	49
2019	2	2	11	5	3	23
Grand Total	**347**	**1142**	**975**	**386**	**97**	**2947**

Table 2 shows the Hagan population by first use year and wattage. Some uranium-only low-wattage containers are not included in this list.

Table 2. Hagan containers by first use year and wattage

Hagan 1st Use Year	> 0 and <= 5 Watts	> 5 and <= 10 Watts	> 10 and <= 15 Watts	> 15 and <=20 Watts	> 20 Watts	Grand Total
1999	53	3	1			57
2000	71	6	3			80
2001	190	23	3			216
2002	127	9	1		1	138
2003	72	29	5	1	1	108
2004	77	15	3	3	1	99
2005	328	49	2		1	380
2006	234	20	3	2	1	260
2007	206	22	1	1		230
2008	134	19	6	1		160
2009	111	8				119
2010	181	23		1		205
2011	85	9	5	3		102
2012	38	5				43
2013	20	2				22
2015	1					1
2016	20	1	1			22
2018	23	2				25
2019	1					1
Grand Total	**1972**	**245**	**34**	**12**	**5**	**2268**

Figure 1 shows another view of the Hagan population - first use year versus A2 threshold. The A2 threshold is defined in Attachment 3 Section 3 of the DOE M441.1-1 manual.[2] Containers above the threshold are subject to the specific M441-1.1 requirements.

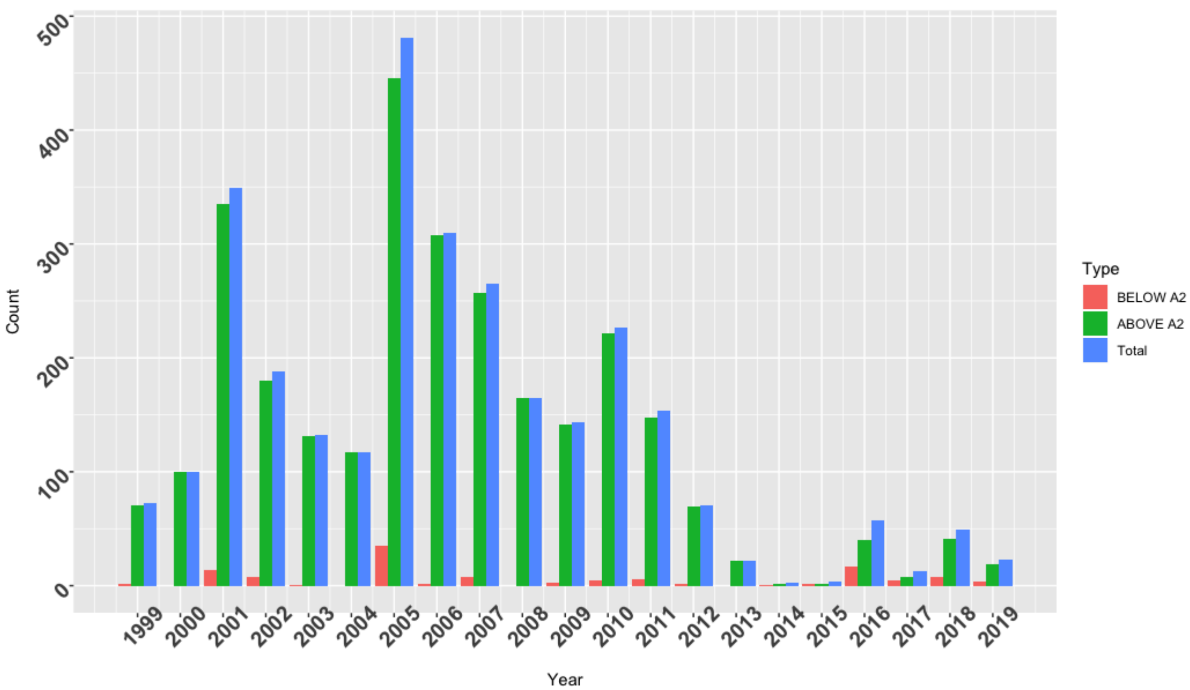

Figure 1. First use year for A2 threshold, red is below threshold, green above, and blue total.

[2] Manual 441.1-1, "Nuclear Material Packaging Manual" Approved: 3-7-2008 Certified: 11-18-2010 Chg 1 (Admin Chg): 2-24-2016

Figure 2 shows the number of Hagans in the vault versus FY.

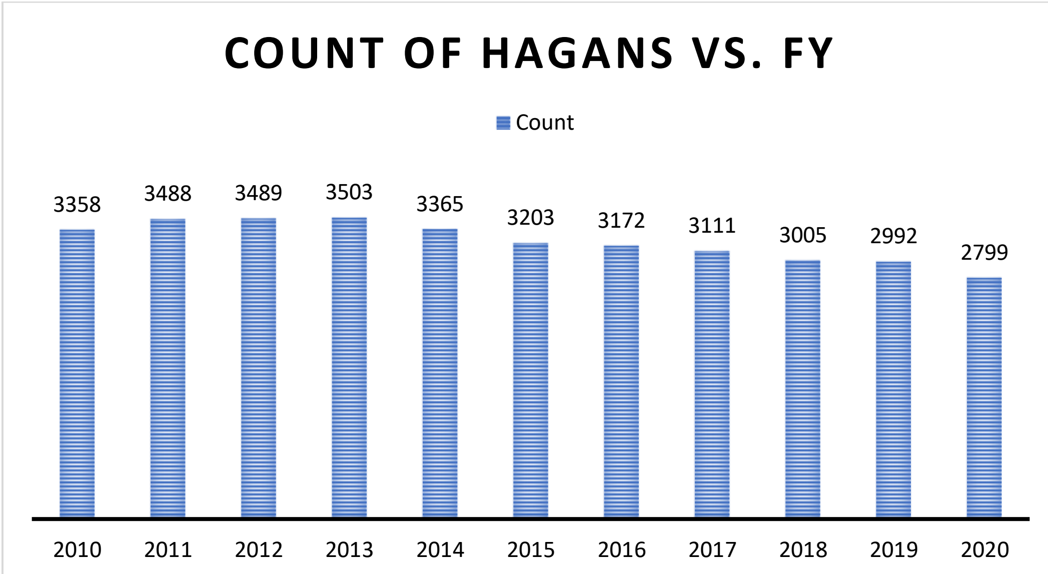

Figure 2. The number of Hagans in the vault versus FY.

There are two significant disposition campaigns planned from 2020 to 2025. The first is the ARIES disposition of 523 Hagans containing mostly plutonium oxide with some metal and residues. The second is the disposition of 573 Hagans loaded primarily with residues as part of the MR&R program. If these programs proceed as planned, the Hagan population will be reduced by 1096 containers for a total of 1703 containers in 2025. However, given current work limitations resulting from the COVID-19 safety requirements and other logistical constraints, there is uncertainty as to the completion date of these programs.

2.2 Potential Failure Modes

2.2.1 Failure Due to Seal Loss Over Time or Improper Closure

Due to the threaded design of the Hagan container with minimal O-ring compression at closure, it is estimated that 20% of Hagans have a helium leak rate $\geq 1.0 \times 10^{-5} stdcc.atm/sec$. Primary evidence of this is that some visual examinations of Hagans show corrosion in the threads past the O-ring boundary, indicating that the O-ring lost its seal. These containers, with such difficulty in opening, tend to be introduced and not available for leak testing.[3] Leak testing to date only occurs on empty containers that have been re-seated, so the leak test does not necessarily reflect the as found loaded condition. Containers have been found to be under-tightened as well as overtightened. This issue may be complicated by the fact that the closure markings did not account for tolerances of the nominal O-ring thickness; thicker than nominal values but still within tolerance did not allow the lid to line up and thinner O-rings allowed the user to pass the markings. Under-tightening can cause a leak by not applying an adequate compression to create a seal. Overtightening can cause the container to seize shut making it difficult to re-open the container. In this case, the lid can apply excessive torsion onto the O-ring, the resultant shear stress can cause the O-ring to slip out of the groove resulting in the lid being

[3] Karns et al., "Surveillance Report", LA-UR-19-32444.

closed with a kink in the O-ring. The O-ring can develop deep permanent creases that create a leak path or tear in the O-ring that will also cause failure of the seal. This failure was observed in an FY17 SAVY surveillance Hagan (Container body: 07/02-03261 Lid: 8/02 LANL 1061 NFT 01).[4] This container failed O-ring visual inspection because the O-ring had two significant creases on it from the lid being closed onto the O-ring while not properly seated in the groove. In addition, the container failed helium leak testing with an established Hagan acceptance criteria helium leak rate of $\leq 1.0 \times 10^{-5} stdcc.atm/sec$.

2.2.2 Failure Due to Container Design Issues

A major factor with the Hagan container not properly sealing lies within the groove design. The Hagan container was designed to provide a face seal through a 70 durometer O-ring within a narrow O-ring groove with no tools needed to close the container. The O-ring groove was designed narrower than Parker O-ring recommends. The Hagan uses a Viton compound Parker O-ring, part number 2-171 with a nominal thickness of .103±.003 inches. Dimensions of the O-ring groove on the Hagan have a depth of 0.080" x 0.105" wide, which is narrower than recommended. The Parker O-ring Handbook recommends the following for designing a face seal O-ring groove for part: 2-171, Figure 3 and Table 3 below illustrate what each groove depth and width should be according to specific O-ring sizes.

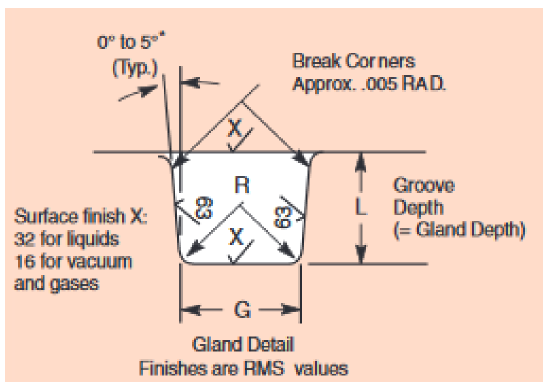

Figure 3. Parker Handbook diagram for designing face seal o-ring grooves

Table 3. Corresponding Parker o-rings sizes for groove design

O-Ring Size Parker No. 2	W Cross Section Nominal	W Cross Section Actual	L Gland Depth	Squeeze Actual	Squeeze %	G Groove Width Liquids	G Groove Width Vacuum and Gases	R Groove Radius
004 through 050	1/16	.070 ±.003 (1.78 mm)	.050 to .054	.013 to .023	19 to 32	.101 to .107	.084 to .089	.005 to .015
102 through 178	3/32	.103 ±.003 (2.62 mm)	.074 to .080	.020 to .032	20 to 30	.136 to .142	.120 to .125	.005 to .015

[4] Ibid.

The recommended groove width for the Hagan O-ring should be at least 0.120", which would allow the O-ring to laterally expand during compression. Currently, due to the narrower groove, an excessive amount of force is required to achieve the squeeze of 0.02" or 20% that is recommended by Parker with the narrower groove size without mechanical advantage. In a calculation study AET-CW-CE-17[5] Finite Element Analysis (FEA) was used to determine the actual amount of squeeze achieved by the 8 quart Hagan groove design by the amount of torque applied by a worker. It was determined an applied torque of approximately 100 in-lbf on the O-ring at closure only resulted in approximately 2% of actual squeeze, or 0.002" change in O-ring thickness. With a low squeeze value, the Hagan O-ring can be expected to quickly take a compression set resulting in the container having a gross leak.

Additionally, the degradation of the gasket seal underneath the filter of the Hagan container has also been an area of concern. This crumbling gasket could be the sign of a known condition of gasket material that was identified by the manufacturer to be out of tolerance and documented accordingly. Surveillance will include an assessment of the gasket, which could provide insight to a semi-risk level status of the container based on a visual inspection. Specific details regarding this topic can be found in TA55-NCR-2008-002, *Nonconfroming 2002-Dated Nuclear Material Container Filter Gaskets*.

2.2.3 Failure Due to Corrosion

The use of sPVC bag-out bags as the packing material results in the production of corrosive gases due to the irradiation of the sPVC. Irradiation of PVC causes degradation of the sPVC through the dehydrochlorination (DHC) of PVC polymer backbone (double-bond formation, polymer cross-linking and chain scission).[6] This results in PVC discoloration, brittleness and loss of strength as well as production of HCl gas. This issue is exacerbated when storing materials high in Am-241, such as MSE salts, due to the high alpha and beta/gamma dose. The vented design of the Hagan container allows moisture to pass in and out of the containment boundary. The combination of HCl and moisture supplied by humid air exchanges with the air inside the container due to local atmospheric changes results in corrosion of the container body.

As part of the SAVY surveillance program, a total of 45 Hagan container examinations have been performed as of the end of 2020.[7,8]. Corrosion has been observed in 27 of the Hagan containers. Of the 27 Hagan containers showing corrosion, 22 were loaded with materials that were identified as worst-case materials, with usage ages up to 18 years.

In the SAVY surveillance program, the severity of corrosion in a container is given a ranking based on the visual inspection. The ranking of 0 to 3 is based on the extent of the coverage of the interior surfaces with general corrosion. A ranking of 0 indicates that no corrosion was observed, a ranking of 1 indicates light or isolated general corrosion and a ranking of 3 indicates heavy general corrosion.

---

[5] Hill et al, "Calculation Worksheet AET-QP-GEN-18A, Rev. 0, March 14, 2005, Calculation Document Number AET-CW-CE-17, Hagan 8 Quart Container O-ring Compression Analysis"
[6] Andrea Labouriau et al., "Accelerated Aging Study of Replacement Candidates for PVC Bag-out Bags" FY20 Report, LA-UR-20-22574
[7] Karns et al., "Surveillance Report", LA-UR-19-32444.
[8] Narlesky, Joshua E. et al., "Evaluating Corrosion Effects on the Stainless Steel Components of the SAVY-4000/Hagan Nuclear Material Storage Containers: FY19 Update" LA-UR-19-28813, Los Alamos, NM, 2019.

Corrosion has been observed outside of the sealing surfaces of five Hagan containers to date. Deposits of corrosion products on the threads resulted in the lid becoming fused to the body. Deposits of corrosion products on the sealing surfaces of Hagan containers has resulted in containers failing helium leak testing. The FY18 SAVY surveillance Item of Opportunity Hagan, container body: 03 06-05072 lid: LANL-691 had extensive general corrosion and failed the initial helium leak test that was performed prior to cleaning. After cleaning the O-ring and O-ring groove and re-testing,[9] the container failed the helium leak test again. The corrosion residue was severe enough that it could not be completely removed by Fantastik® and alcohol wipes causing the container to be deemed a failure.

Pitting has been observed in three Hagan containers (Figure 4) that had been selected for optical microscopy based on the extensive general corrosion observed in the visual inspection. Corrosion pits with diameters up to 160 microns were observed. Depth measurements were not performed, but estimates indicate that the depths could be up to 40 µm (less than 5% of the total wall thickness) based on the focal length of the optical microscope being used. The ages of these containers ranged from 8 to 13 years.

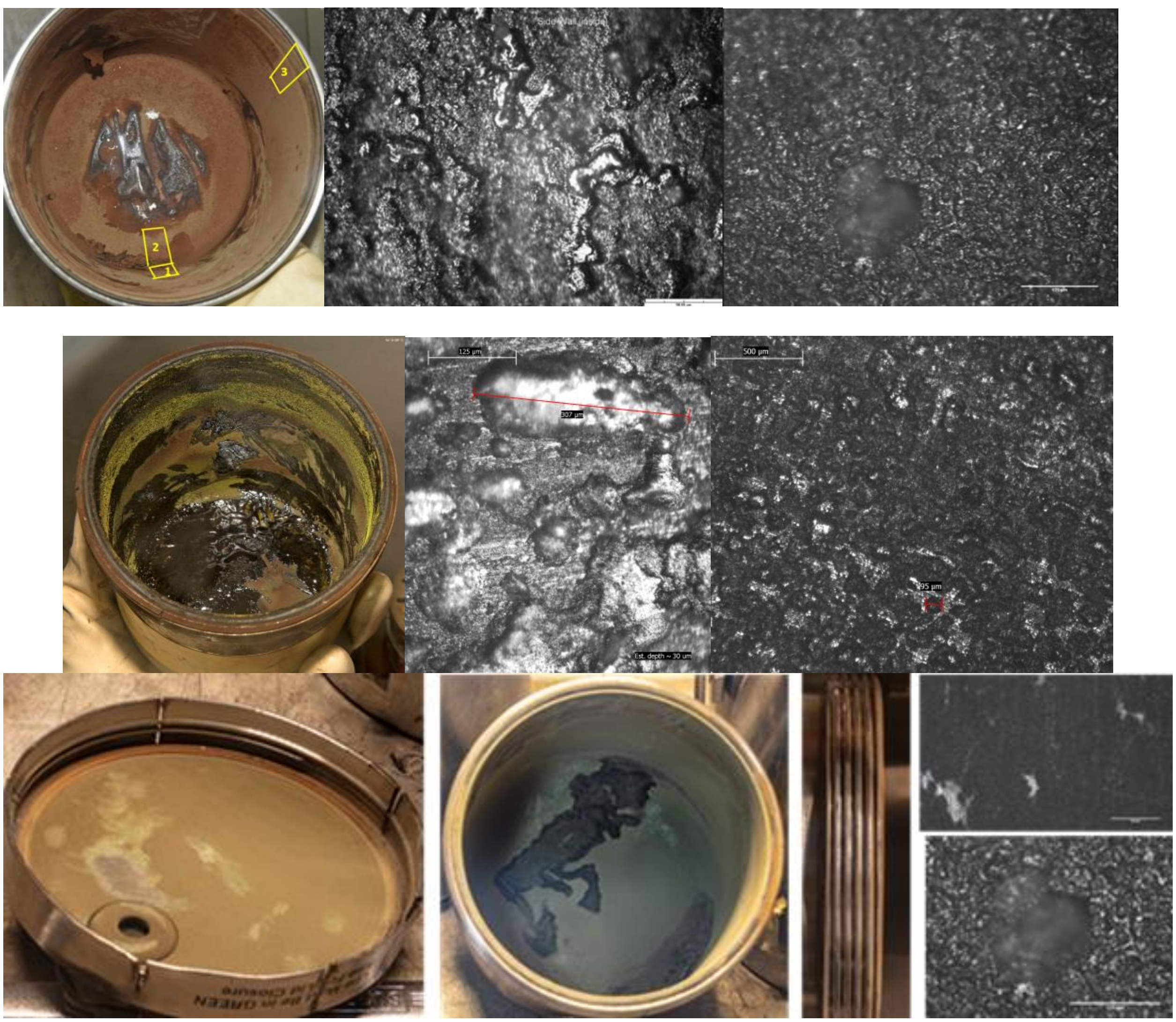

Figure 4. Pitting observed in 3 corroded Hagan containers

[9] PA-AP-01197, "Nuclear Material Container Surveillance Inspection for Container Integrity and O-Rings"

In addition to pitting, a concern for Hagan containers is a through wall crack resulting from stress corrosion cracking (SCC) of stainless steel. The SAVY corrosion working group has performed a series of experiments to evaluate the susceptibility of the Hagan body to SCC. Boiling magnesium chloride testing has shown the weld region to be most susceptible to cracking. Residual stress measurements show a significant hoop stress in that region. Accelerated corrosion studies, which expose Hagan container bodies to a moist HCl environment have shown small cracks developing at the bottom of corrosion pits. Although these results indicate that SCC can occur under bounding conditions, SCC has not bee observed during visual inspections of Hagan containers.

3.0 Hagan Surveillance Data Collection

This section describes the plan for collecting Hagan surveillance data. This plan leverages several existing programs, including the Hagan disposition initiatives. Hagan surveillance is expected to provide needed information on the integrity of containment for materials in the population of Hagan storage containers within a 5 year surveillance time frame.

3.1 Leveraging In-Service Inspections (ISI) Information

Currently there is an ISI program that inspects a number of Hagan containers annually. The inspection consists of determining a) wear and degradation, b) location at or below the applicable performance criteria height, and c) appearance of being properly and fully closed. Copies of completed ISIs can be found on the TA-55 network “OperationCenterShareDrive” folder. The Hagan surveillance program will incorporate this information as appropriate.

3.2 Leveraging ARIES and MR&R Disposition and the APU Pilot Program

As noted previously, the ARIES program plans to disposition 523 Hagans and the MR&R program plans to disposition 573 Hagans over the next five years. These disposition efforts provide an opportunity to collect invaluable data for evaluating the condition of the Hagan population now and in the future. In addition, a collaborative surveillance effort will benefit the MR&R program by improving knowledge of what is in the legacy container population. This will provide information for acceptable knowledge (AK) documentation and will increase understanding of what issues might arise during MR&R activities. These surveillance activities will also be coordinated with the APU pilot program (Davis, et al., 2020). The coordination between MR&R, ARIES, APU and Hagan surveillance provides a unique opportunity for leveraging and sharing of data and knowledge that will be beneficial to all four programs.

A goal of the Hagan/SAVY surveillance team is to gather information on all MR&R or ARIES Hagans, yet not negatively impact disposition activities. To this end there will be two Hagan surveillance activities. One will assess all Hagan containers by defining “reporting points” (Appendix A). The other will identify specific EJ MR&R and ARIES Hagans for Hagan surveillance. Section 3.5 contains the EJ Hagans identified for 2021. These containers include both containers from the MR&R and APU programs. ARIES containers will be included in the future.

3.3 Leveraging SAVY Surveillance

As seen in Sections 3.4 and 4.0, Hagan surveillance incorporates lessons learned from the SAVY surveillance program. The lessons learned include not only findings (e.g., corrosion in containers), but the approaches used for surveillance examinations and sampling.

For example, the worst-case selection criteria developed in the SAVY program have been shown to be effective for identifying containers with corrosion. Hagan EJ containers are identified as worst-case based on the same criteria as those for SAVYs.[10] For example, EJ Hagans will consist of Hagans with the same IDC type as containers that showed corrosion in the past, as well as the previously identified "worst-case IDC groups" not yet examined. For storage containers that fall within the same IDC grouping, preference will continue to be given to containers higher in age, higher in wattage, higher in nuclear material content, and smaller in size. These factors have been found to correlate with the degradation of PVC bags, resulting in higher rates of HCl generation. Bag degradation is an important factor for identifying worst-case Hagan containers. It has been seen that pure oxides with higher wattage, not anticipated to be corrosive in themselves, have shown corrosion. This is an indicator that points to the PVC bags; if the bag had not been present corrosion of pure oxides should not have taken place.

As with the SAVY program, engineering judgment will continue to target material types that would result in higher alpha and/or gamma dose as well as a higher thermal load to the PVC bag. These conditions include continuing examination of Pu-238 (MT-83) containers; the addition of material types not previously examined include MT-82 (Np-237, which has a high gamma dose), and MT-41 and MT-42 (Pu-242, which is high in Am-241and Pu238); and large MT-56 and MT-57 (> 20% Pu-240, which are also high in Am-241).

In addition to the worst case conditions identified in the SAVY Program, environmental factors will be considered during EJ container selection for Hagans. It has been recognized that temperature, RH, cumulative dose, and thermal load from adjacent containers could be important drivers for corrosion. Measurement of temperature and relative humidity will be made where possible at the storage location.

3.4 Hagan Containers Selected for Surveillance in 2021

Table 4 shows the Hagan containers identified for surveillance in FY21. These containers include those selected from the general population based on EJ (green), those selected from MR&R (blue and orange), and two Hagans (gray) with material that will be repackaged into SAVYs as part of the APU pilot project. It is not expected that all of these containers will be examined in FY21. Logistical considerations and constraints will determine which containers are examined, and those containers that are not examined will move to the FY22 list.

[10] Kaufeld et al., "SAVY-4000" LA-UR-19-32605.

Table 4. List of Hagan containers for 2021 surveillance. Green items are EJ containers from general population, gray items are from the APU pilot study, blue items are MR&R containers dispositioned in 2021 and orange items are future MR&R containers.

IDC	MT	Size (QT)	Item	Watt	Pu Wt. (g)	Age (yr)	BDF
R65	52	5	XBSOX441	1.3	488.0	20.1	2.3
R65	52	5	XBSOX431	1.3	484.0	20.2	2.3
R65	52	5	XBS9528	1.3	482.0	12.7	1.4
R65	52	5	XBS9535	1.3	481.0	12.4	1.4
R65	52	3	XBS1487	1.2	473.0	17.8	2.5
R65	52	3	XBS1482	1.0	371.0	19.5	2.2
R65	52	3	XBS8403	1.0	371.0	19.5	2.2
R47	56	5	INC82701	1.8	347.0	14.4	2.2
R47	56	5	INC83101	1.7	339.0	14.2	2.2
R47	83	8	TDC70	9.3	19.7	17.0	9.8
R657	52	8	GBS063*	4.7	1775.0	16.1	4.9
R657	52	8	GBS010*	4.7	1767.0	16.1	4.9
R657	52	8	GBS024*	4.6	1758.0	16.1	4.8
R47	54	5	TDC205	2.1	475	13.8	2.5
R47	54	5	INC22101	1.8	413	15.9	2.5
R833	52	3	XBLSCL4050903	23.8	1491	17.5	47.2
M447	52	5	AAP02MET	8.7	194.8	12.8	10.0
R832	52	1	XBLSCL1207	6.0	372	11.8	17.0
R87	52/44	3	XBLS32	1.0	249.0	13.9	1.7
R32	52/44	3	XBLSCL1120B	1.3	128.0	8.5	1.3
R32	52/44	3	XBLSCL3-98	3.2	286.7	15.8	6.0
R32	52/44	5	XBLSCL1125	0.7	532.1	8.5	0.5
R32	52/44	3	XBLSCL1121	1.5	114.1	10.7	1.5
M441	42	3	GRING17	2.5	363.0	20.7	6.1
M441	42	3	GRING17A	2.7	391.0	20.7	6.6
M441	42	3	GRING20A	0.4	55.0	19.0	0.9
R410	52	8	CXLCAKE022802A**	1.4	2734.4	18.5	1.7
R410	52	12	CXLCAKE051203**	1.2	438.0	17.5	1.0
R657	52	8	GBS010*	4.7	1767.0	16.0	4.8
R657	52	8	GBS024*	4.6	1758.0	16.0	4.8
R657	52	8	GBS063*	4.7	1775.0	16.0	4.8
R652	52	3	XBS9535***	1.3	481.0	13.5	2.0
R652	52	3	XBS9539***	1.4	526.0	13.3	2.2

*Select two, ** Select one, *** Must be done together

4.0 Hagan Surveillance Testing and Analyses

The potential failure modes of the Hagan are described in Section 2. These failure modes include leakage or loss of containment due to one of three issues: incomplete/improper container closure at the time of packaging, incomplete closure related to container design issues (inadequate compression of the O-ring or failure of filter seal), or through wall corrosion.

4.1 Current Surveillance Capabilities

The failure modes related to container design can be addressed by continuing the surveillance testing already performed on Hagans under the SAVY Surveillance Plan. These tests include helium leak testing, O-ring durometer testing, and filter testing (pressure drop and particle penetration). Helium leak testing is used to determine whether complete closure of the container can be achieved. Typically leaks in Hagan containers are related to the sealing surfaces, but helium leak testing may also identify a through wall failure due to corrosion. O-ring and filter testing (pressure drop and particle penetration) can help determine if degradation of these components is occurring and whether these effects are related to age or storage environment. The failure modes related to improper closure of the container are difficult to predict when selecting containers for surveillance, particularly when improper closure is related to operations rather than container design. However, surveillance testing will continue to assess the rate of occurrence of improper closures in the storage population.

Hagans will also be examined for corrosion impacts to address the questions below. These examinations will include destructive sectioning and microscopic examinations as needed.

- Have any inner containers been breached?
- Has stress corrosion cracking occurred? If so, how extensively and how deeply?
- What is the distribution and severity of pitting?
- Comparing results with pit growth models based on earlier data, can we update the model predictions and achieve high confidence in predictions of future maximum pit depths?
- Do observed pit morphologies and sizes suggest future SCC?

4.2 Establishing Additional Surveillance Capabilities

Optical microscopy is currently performed on select containers which have been identified as having the most extreme corrosion. This has provided the SAVY program with valuable data with respect to the sizes of pits that have formed in some containers. However, the data obtained by optical microscopy is limited to measurements of a few pit diameters on a few containers. In the future, laser confocal microscopy (LCM) can be used to obtain quantitative analyses of the pitting (width and depth), and is better suited to locate small cracks and could be used to assess whether SCC is occurring in the storage population. Additionally, pit depth distributions obtained by LCM analyses will help to identify aging or environmental effects related to corrosion.

One of the difficulties associated with the surveillance of older containers is the potential for radioactive contamination on the inside surface of the outer container (or containers that are actually contaminated). As a result, many Hagan containers are introduced into the glovebox line at the time of opening and a complete suite of analyses cannot be performed. Establishing in-glovebox surveillance capabilities will ensure that the three failure modes are addressed at least in a limited fashion.

It is proposed that in-glovebox helium leak testing be performed with an existing system. In this system, contaminated containers for testing in the glovebox line will be unloaded and cleaned prior to testing. Each container will then be connected to a helium leak detector using an adaptor that attaches to the container vent. This testing will be conducted using a helium leak detection system installed in a glovebox used for 3013 surveillance studies. This system differs from the current system used for container surveillance outside of the glovebox in that it is set up to perform helium leak testing under vacuum. Therefore, testing will be conducted to determine whether this system can be used for Hagans.

LCM analysis of contaminated containers requires cleaning of contaminated metal. An established process exists in PF4 for the cleaning of contaminated metal specimens and removal from the glovebox line. This process will be used to clean the selected contaminated Hagan specimens for LCM examination.

In addition, enhancements in non-destructive testing techniques, including the Modular Non-destructive Test System (MINTS)[11] (Figure 5), provide a strong technical, financial, and environmental solution for analyzing plastic deformation and corrosion of nuclear material storage containers. The MINTS system combines ultrasonic (UT) and eddy current (ECA) detectors on a single platform and its utility to test containers has been demonstrated. The use of MINTS in the surveillance program is expected to reduce the number of destructive tests necessary.

Figure 5. MINTS Table (front view)

[11] Vaidya, R. U. et al., "Application of Non-Destructive Testing to Assess Corrosion Damage in Nuclear Material Storage Containers", LA-UR-19-23273; Los Alamos National Laboratory: Los Alamos, NM, 2019

5.0 Database Management

LANMAS contains important container information such as the age of the container, how long it has been in service, and its in-service history (e.g., what materials have been loaded for what periods of time). LANMAS also provides information about the materials in the containers, so that a material causing potential problems can be identified.

When possible Hagan surveillance items are to be placed on a feedlist prior to surveillance activities and items will be assigned to the LANMAS field SubMBA or MMGT. The MMGT identifier prevents the containers from being retrieved from the vault without notification, so that surveillance processing can take place.

Results from the Hagan surveillance will be integrated into the Surveillance Information System (SIS) as described in the 2020 SAVY Surveillance Update.[12] The SIS is comprised of multiple data sources, including the following:

1. LA Authors
2. LANMAS
3. NucFil manufacturing quality data and Source Inspection data for SAVYs
4. Secured SAVY and Hagan Surveillance Information
    a. The Hagan data will include surveillance data for both EJ and Reporting-point Hagans, and for those Hagans that are dispositioned without reporting points and are therefore assumed to have no potential problems.

6.0 Summary

Currently Hagans play a major role in storing nuclear materials and contain some of the most challenging materials, as the higher risk contents (prior to SAVY implementation) were loaded into Hagans to mitigate that risk. Although there are plans for ARIES and MR&R disposition of Hagans over the next five years, even at that time there will be over 1700 Hagan containers in service.

A number of key factors unique to the Hagan storage container design are important indicators of the integrity of the Hagan container population. This focused Hagan surveillance program will assess these factors and thereby provide enhanced assurance of the safe handling of the containers now and in the future. In addition to Hagan design issues with the potential for leakage, Hagan surveillance includes evaluation of corrosion concerns and the assessment of material properties that present a challenge to the integrity of the containers. This effort supports the intent of the Container Safety Management Program (CSMP) by monitoring and mitigating risk with existing non-Manual compliant storage container use.

This initiative will ensure the safe usage of Hagan containers through a comprehensive evaluation of the Hagan population potential failure modes and the ability to predict and mitigate

[12] Kaufeld, et al., "SAVY-4000" LA-UR-19-32605

potential failures over time. After five years of surveillance and the removal of many Hagan containers from the population through disposition, the need for continued surveillance could be reduced significantly; possibly limiting future surveillance to a small target group.

This Hagan surveillance plan will be evaluated annually and updated as needed.

7.0 References

Andrea Labouriau et al., “Accelerated Aging Study of Replacement Candidates for PVC Bag-out Bags” FY20 Report, LA-UR-20-22574

Hill et al, “Calculation Worksheet AET-QP-GEN-18A, Rev. 0, March 14, 2005, Calculation Document Number AET-CW-CE-17, Hagan 8 Quart Container O-ring Compression Analysis”

Karns, Tristan et al., “Surveillance Report on SAVY 4000 and Hagan Nuclear Material Storage Containers Update for Fiscal Year 2019”, Los Alamos National Laboratory report LA-UR-19-32444, December 2019.

Kaufeld, Kimberly Ann et al., “Los Alamos National Laboratory SAVY-4000 Field Surveillance Plan Update for 2020” LA-UR-19-32605 Issued: 2019-12-20 (rev.1)

Narlesky, Joshua E. et al., “Evaluating Corrosion Effects on the Stainless Steel Components of the SAVY-4000/Hagan Nuclear Material Storage Containers: FY19 Update” LA-UR-19-28813, Los Alamos, NM, 2019.

Manual 441.1-1, “Nuclear Material Packaging Manual” Approved: 3-7-2008 Certified: 11-18-2010 Chg 1 (Admin Chg): 2-24-2016

PA-AP-01197, “Nuclear Material Container Surveillance Inspection for Container Integrity and O-Rings”

Vaidya, R. U. et al., “Application of Non-Destructive Testing to Assess Corrosion Damage in Nuclear Material Storage Containers”, LA-UR-19-23273; Los Alamos National Laboratory: Los Alamos, NM, 2019

Appendix A – Reporting Points for MR&R and ARIES Programs

The reporting-point approach is designed to **minimize** the need for MR&R or ARIES staff to collect data on disposition containers. The reporting points below are those conditions where a Hagan container is not immediately disposed of, rather the Container Safety and Engineering team is notified (contmgmt@lanl.gov) and a container team member can have the container moved to an appropriate area for more detailed examination, take photographs and/or release the container for disposal. By default, this reporting-point approach provides data for all containers, since those not identified as having a hold point are considered not to have any potential problems of concern. Note that these reporting points are also used for SAVYs.

Operators are already required to report suspected or identified packaging issues per the contingencies section 5.3 TA55-DOP-091, TA-55 Nuclear Material Packaging. In addition to the reporting requirements stated in the current version of the operating procedure, the Container Safety and Engineering team requests notification (contmgmt@lanl.gov) when any of the following are observed:

- Contamination detected on <u>Outer</u> Container (inner or outer surfaces)
- Corrosion outside of sealing surface (e.g. on Hagan threads, outside of filter, on TID wire, outside surfaces of lid or body)

- Corrosion covering >95% of inside surface (little to no bare metal visible)

- White powder outside of sealing surface (e.g. near filter)

- O-ring missing
- O-ring crimped or damaged

- Bulging or paneling
- Dents > 1 inch in diameter
- SAVY filter with visible damage (e.g. hole(s)) (appropriate for SAVYs only)